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ABSTRACT

This study explored the stability and interjudge agreements of a sociometric scaling device to which children could easily respond, which teachers could easily administer and score, and which provided scores that researchers could use in parametric statistical analyses. Each student was paired with every other member of his class. He voted on each member as "below me" or "above me" in arithmetic problem solving ability. A classroom matrix was constructed showing proportion of self and peer votes on the trait judged, and an arcsin transformation was used to obtain normality. Teachers also judged each student in the class. In the study, distributions of self, peer and teacher nominations were analyzed for a 501 member pupil sample and their 22 teachers. Results indicate that the arcsin transformation of proportions produces a justifiable interval scale. Pretest and posttest comparisons over six months indicate (1) high reliability of sociometric nominations, and (2) differences of raw score distribution patterns between self, peer, and teacher nominators. Peers were the most accurate predictors of achievement on both occasions. (Author/DG)

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DEVELOPMENT OF A SCALING TECHNIQUE FOR SOCIOMETRIC DATA

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Rationale

Sociometric devices provide a method of ordering and assigning relative positions to individual members of a group with reference to one or more criteria. Moreno (1941) used the technique to determine attractions and repulsions among group members.

Jennings (1948) and Cartwright and Zander (1960) each provided extensive reviews of literature about the use of sociometric "tests." Both reported advantages of sociometric techniques as (1) providing a method of quantifying patterns of social choice and (2) providing a means of analyzing both individual and group choice behaviors. They also noted a scarcity of scaling techniques for the sociometric data.

Scaling of sociometric responses poses a major problem. Jennings (1948) indicated that the primary tool for displaying sociometric data was the sociogram, which is essentially a graph of lines of attraction. Most often nominated members generally appear at the center of the graph and are commonly called "stars." Least often nominated members appear at the extremities of the graph, and they are identified as "isolates."

Traditional techniques for scaling sociometric data describe dyads and the magnitude of social attractions but they do not order individuals within a classroom. The abundant psychometric literature on empirically tested theoretical scaling models for judgmental data provided a theoretical basis for the current study.

Thurstone's Law of Comparative Judgment (1927) assesses inter-judge variability or the magnitude of discriminal dispersion between sets of adjudged paired stimuli. The paired-comparisons task is the

general methodological tool used in forming judgmental scales based on this model. Folgmann (1933) developed a scale of composer preferences for outstanding symphony orchestras using the Thurstone model. Bendig (1958) also used the model to develop scales to compare the reliability of self ratings and predictions of others' ratings in a food preference study.

Stevens (1936) postulated a direct scaling technique based on estimated differences in magnitude between stimuli. Guilford (1954) reported a further direct scaling model based on estimated ratios of stimuli distances from a postulated standard. Torgerson (1965) catalogued several theoretical approaches to scaling in a single text. Essentially there are two approaches to judgmental scaling. One, called direct, uses estimates of magnitudes in the tradition of Stevens or ratios in the format recommended by Guilford. A second method, indirect scaling, employs direct comparisons of stimuli in pairs. By summing the choice totals of a particular stimuli and dividing by $p + q - 1$, one indirectly obtains a proportionate value for each stimuli considered q ways. The latter method offers a refined method for comparing stimuli, but it also proves time consuming and tedious unless care is taken in designing the comparison task.

Comparisons of direct and indirect scaling techniques have been undertaken in the last decade by Magnusson (1963), Kunnapas and Wikstrom (1963), Ekman (1964), and Magnusson (1965) at the Psychological Laboratory of the University of Stockholm. Although this series of studies seemed to indicate a high degree of positive relationship between all techniques, the indirect technique of paired-

comparisons offered more potential for establishing accurate interval magnitudes.

Since there are scant data indicating the magnitude of difference among individuals in sociometric studies, the present study employed the paired-comparisons technique to provide as much refined information about interval place values of stimuli as possible. The purpose of this study was, therefore, to develop a scaling technique which would permit assignment of interval scale values to individual nominees based on the frequency of nomination by other members of the group (peers), by self and by teacher. This would then permit parametric analysis of sociometric data. The tests and the techniques were pretested in a prior study (Peper and Chansky, 1970) using non-parametric analysis.

Procedures

Sample Selection

Five hundred and one fifth grade pupils and their twenty-two teachers from eleven elementary schools participated in the study. The pupil sample was stratified according to population proportions in center city, suburban, rural farm, and rural non-farm communities in the States of New Jersey and Pennsylvania. Class size was restricted to a minimum of twenty pupils and a maximum of thirty pupils, and the grouping for instruction was limited to self contained classes of pupils with mixed ability levels.

Test Administration

A pretest battery was administered to all pupils and their

teachers in September of 1968, and a posttest was administered in February of 1969.

Pupil Tests. A sociometric questionnaire asked each pupil of twenty-two separate classes to nominate other members as "above me" or "below me" in arithmetic problem solving by placing a check in the appropriate column beside the names of pupils on a class roster.

Teacher Tests. Each teacher was provided with a booklet of pupil rosters with each individual pupil serving as the comparative stimulus for the roster of his classmates on a separate page. The teacher was asked to mark every other pupil on the page roster as "above" or "below" the stimulus pupil with respect to arithmetic problem solving ability.

Test Scoring

Pupil Data. Nominations were coded as plus (+) or minus (-) and placed in rows of a matrix with each cell corresponding to a numbered pupil. By summing row minus (-) values and dividing by N-1, a self nomination proportion was established for each member. By summing the column minus (-) values and dividing by N-1, a peer nomination proportion was computed.

Teacher Data. The teacher responses were similarly coded and placed in a matrix. Since there were high reliability coefficients between row and column values, the column values were arbitrarily selected as a means of reporting teacher responses.

Data Analysis

Histograms were plotted of all of the distributions of self, peer and teacher esteem for pupils on both occasions. Although

each of the four demographic regions was treated separately and in more detail in an earlier document (Peper, 1969), this paper will be limited only to the findings of the total sample since the subsample distributions of the sociometric data tended to resemble the distributions of the total sample.

A Kolmogorov-Smirnov analysis of each distribution was conducted to determine if it was normal. Since there were instances of departures from normality of some of the distributions, an arcsin transformation was made of all of the sociometric variables, and each new distribution was plotted. Kolmogorov-Smirnov analyses were then conducted on each of the new distributions and all data were found to be normally distributed.

Product moment correlations were then computed to determine stability of judgments.

Finally, to indicate the predictive validity of the techniques, product moment correlations were computed between the sociometric variables and scores on an arithmetic problem solving subtest of the Iowa Tests of Basic Skills which was also administered concurrently with the sociometric tests.

Findings

Distributions of Raw Scores

Figures 1 through 6 are the histograms of the distributions of self, peer and teacher estimates of pupil's arithmetic problem solving ability.

Insert Figures 1 through 6 Here
(See Pages 11 through 16)

Tests for Normality of Raw Score Distributions

Table I is a report of the results of separate K-S tests of the raw score distributions for congruence with the unit normal curve.

Insert Table I Here
(See Page 23)

Transformation

All sociometric raw score values were transformed using the following general formula:

$$X_{transformed} = \arcsin \sqrt{X_{proportion}}$$

Where arcsin $= \theta = \pi/2 =$ radians

and $.01 \leq X_{proportion} \leq .99$

Table II is a listing of the transformed values for each proportion.

Insert Table II Here
(See Page 24)

Distributions of Transformed Scores

Figures 7 through 12 are histograms of the distributions of the transformed self, peer and teacher estimates of pupils' arithmetic problem solving ability.

Insert Figures 7-12 Here
(See Pages 17 through 22)

Tests for Normality of Transformed Score Distributions

K-S tests of the transformed sociometric data showed no significant departures from normality ($p \leq .05$). Nevertheless, one notes that the self-esteem data give a closer approximation to normaility than do the others.

Coefficients of Reliability and Prediction

Table III is an intercorrelation matrix of the product moment coefficients of correlation between each of the sociometric variables and also arithmetic problem solving scores. It is evident that peer judgment correlates less with self than it does with teacher judgment. Correlations for pretest data are very similar to those for posttest data. Test and retest coefficients indicate that the peer judgment is most stable. Least stable, with a coefficient of .57, was the self judgment variable.

The correlation between arithmetic and esteem is approximately .35, suggestive of modest predictive validity.

Insert Table III Here
(See Page 25)

Rating Tendencies

Table IV is a report of the means and standard deviations of the three nominating groups both in raw score proportions and in transformed score values.

Insert Table IV Here
(See Page 26)

Discussion

The findings of this study may be summarized as follows.

1. The distribution of self esteem raw score proportions was found congruent with the unit normal curve.

2. Peer esteem was not normally distributed. Rather the distributions tended to be positively skewed.

3. Teacher esteem for pupil scores were non-normally distributed in a flat curve with the extreme values evenly weighted with central values.

4. Arcsin transformation of all variables forced unit normal distributions.

5. Self esteem scores were significantly related on both occasions tested (r=.57).

6. Peer esteem was more strongly related on both occasions than was self esteem (r=.83).

7. Teacher esteem was more highly related on both occasions (r=.73) than was self esteem, but less related than the two peer esteem intercorrelations.

8. Self esteem was a significant predictor of arithmetic achievement (r=.27 and .34).

9. Peer esteem was a more accurate predictor of arithmetic achievement (r=.42, 44) than self esteem and teacher esteem for pupils.

10. While teacher estimates of pupil performance were slightly more accurate (r=.33, .35) than self estimates, they were lower than peer estimates of performance.

11. The teachers' mean scores fell at mid-point in the distribution of possible percentages, but were more variable than were self or peer estimates.

12. Self was chosen over peers on the average about sixty per cent of the cases while peers were chosen approximately forty per cent of the cases.

13. Self choice behavior was less variable than peer choice behavior.

Conclusions

Sociometric data distributions vary considerably with nominating groups. Self estimates of arithmetic performance are normally distributed, while peer and teacher choice behavior are not normally distributed. To perform parametric studies using different nominating groups seems to require a transformation of all distributions to a common scale. In this study, the arcsin transformation proved appropriate for normalizing all of the distributions. Hence, the resultant interval scale achieved a demonstrated linearity.

All sociometric variables used in this study proved to be significantly related to arithmetic achievement and hence predictors of arithmetic achievement. However, the coefficients of correlation between the sociometric variables and arithmetic achievement were generally lower than reported general abilities tests and achievement.

The relatively high pretest to posttest intrarelationships between all of the variables and particularly the teacher and peer variables suggests that an early achievement social order is established and that that order persists. Peers were more accurate predictors of achievement on both occasions. Peers' intrarater coefficients of correlation were higher than teacher or self, suggesting that peer nominations are the most stable of the three sociometric variables. They certainly are more reliable and are higher in predictive validity than either teacher or self.

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APPENDIX A

Figures and Tables

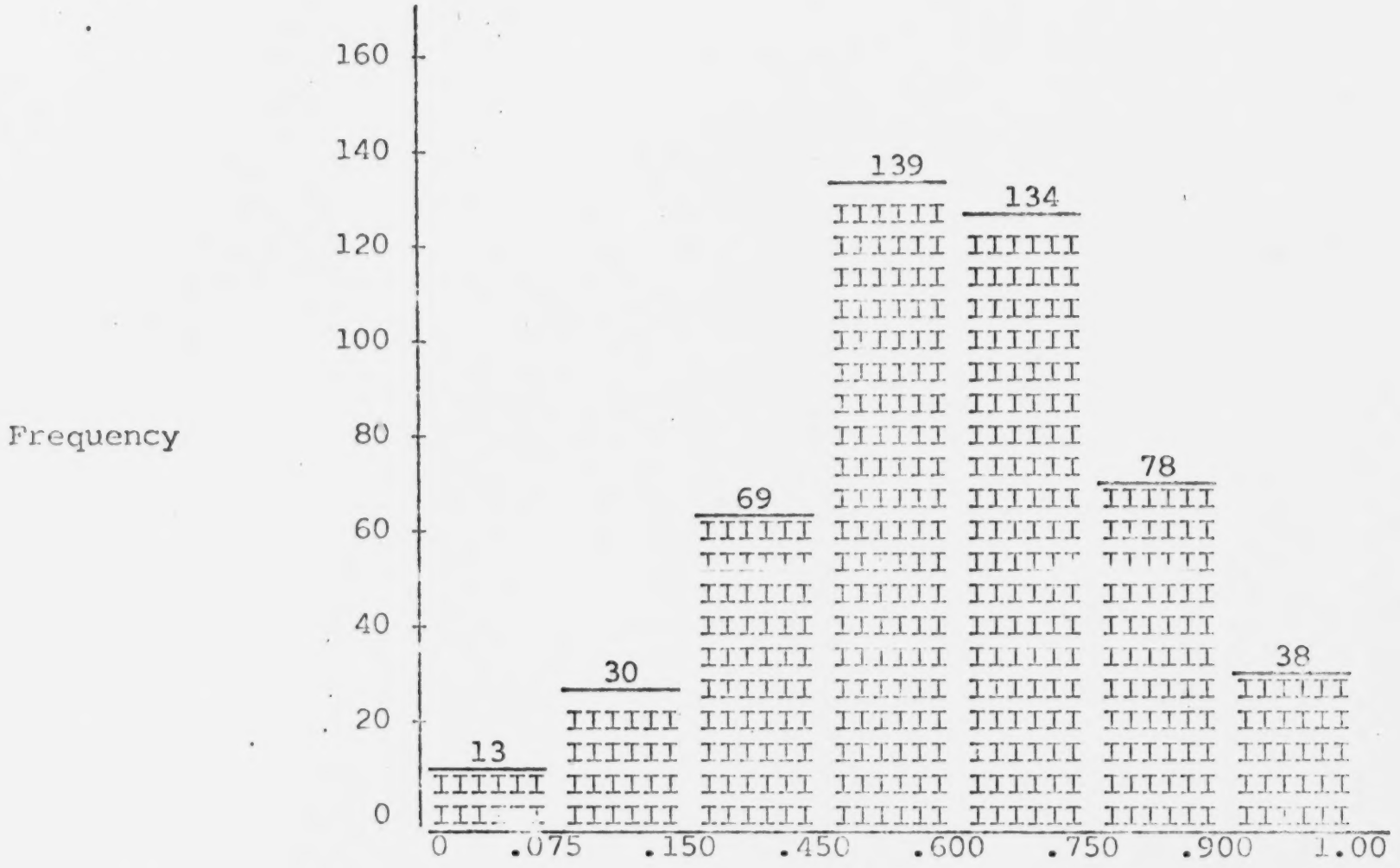

FIGURE 1

PRETEST SELF ESTEEM HISTOGRAM OF RAW SCORE PROPORTIONS FOR TOTAL SAMPLE

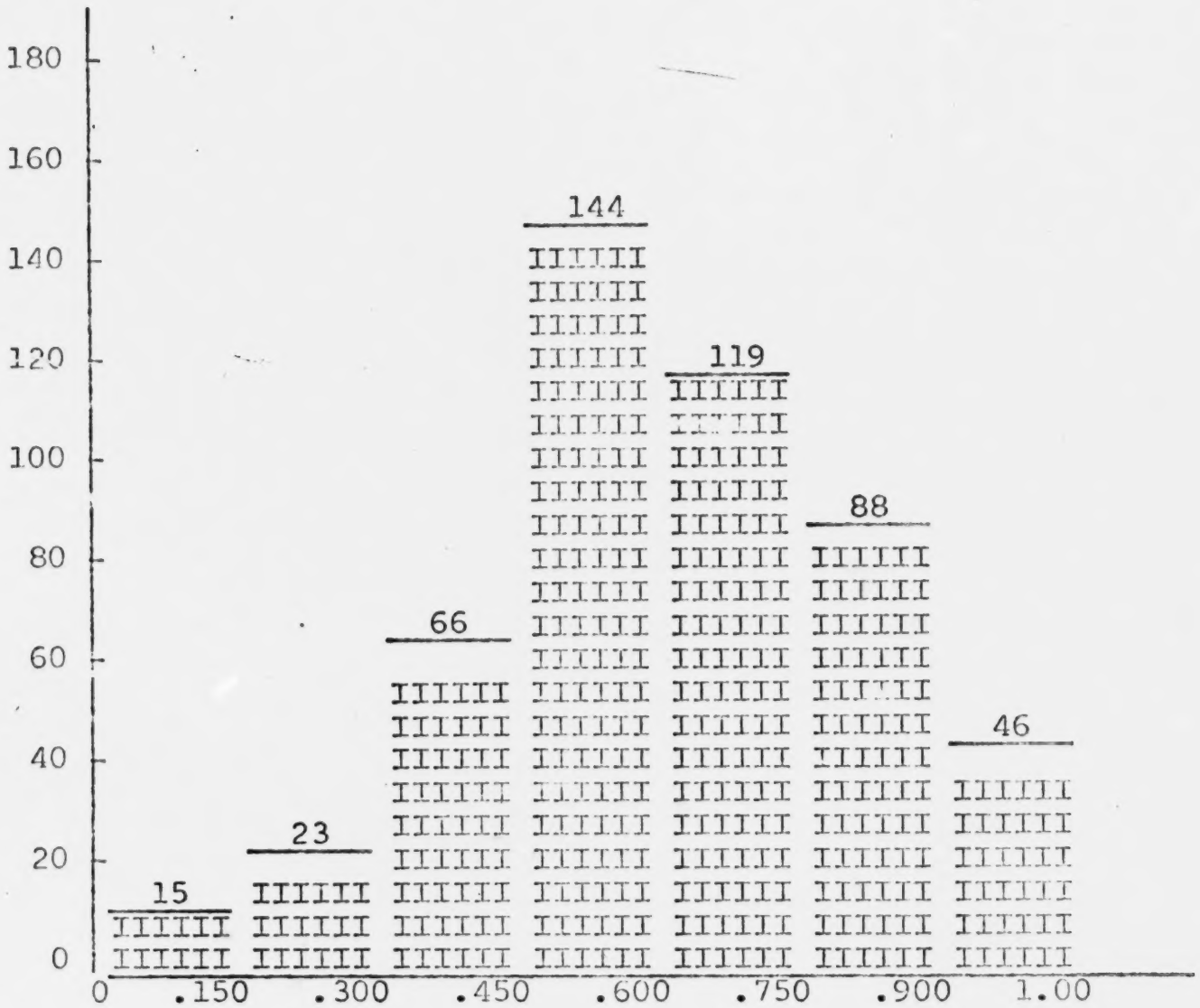

FIGURE 2

POSTTEST SELF ESTEEM HISTOGRAM OF RAW SCORE PROPORTIONS FOR TOTAL SAMPLE

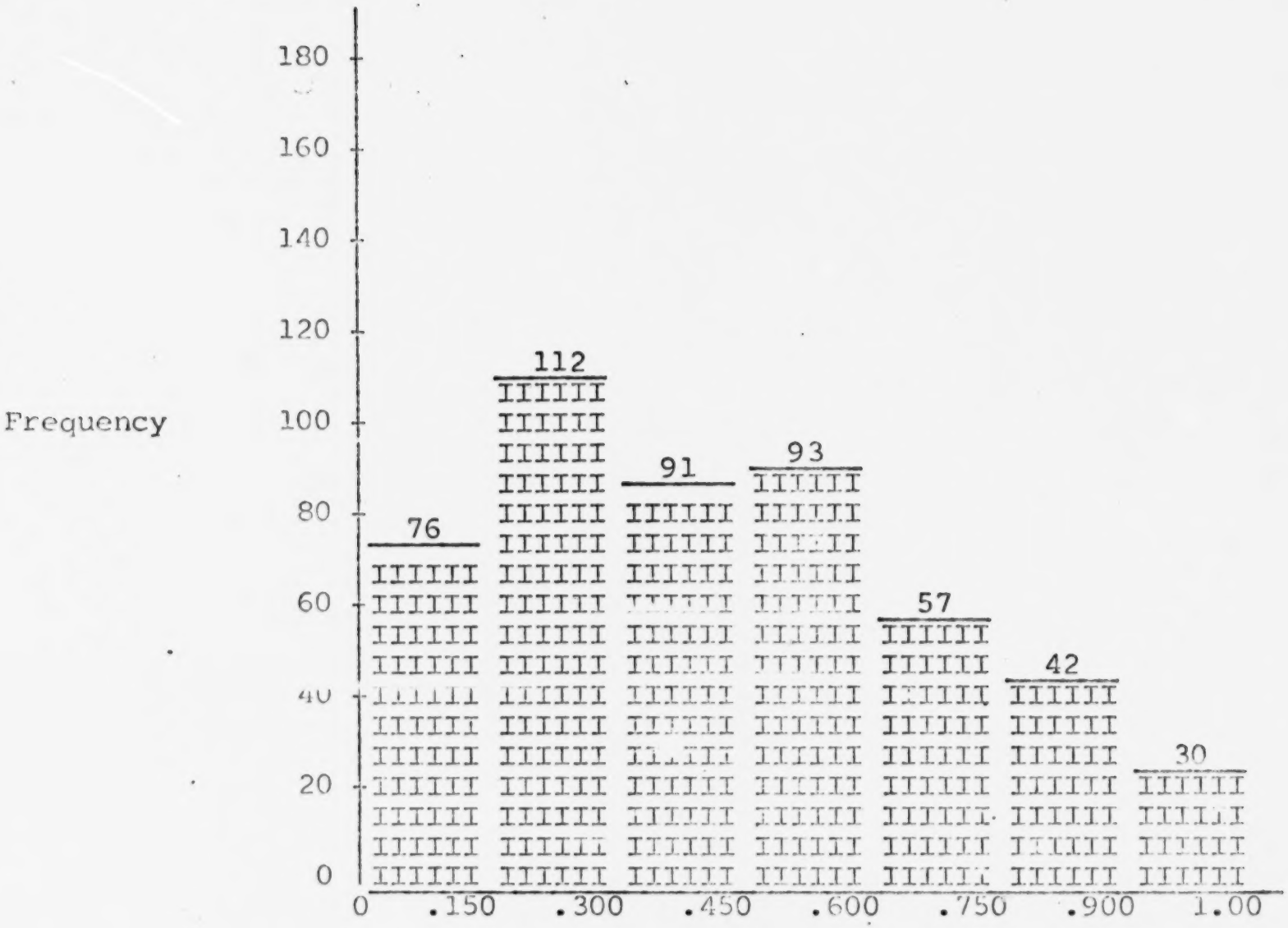

FIGURE 3

PRETEST PEER ESTEEM HISTOGRAM OF RAW SCORE PROPORTIONS FOR TOTAL SAMPLE

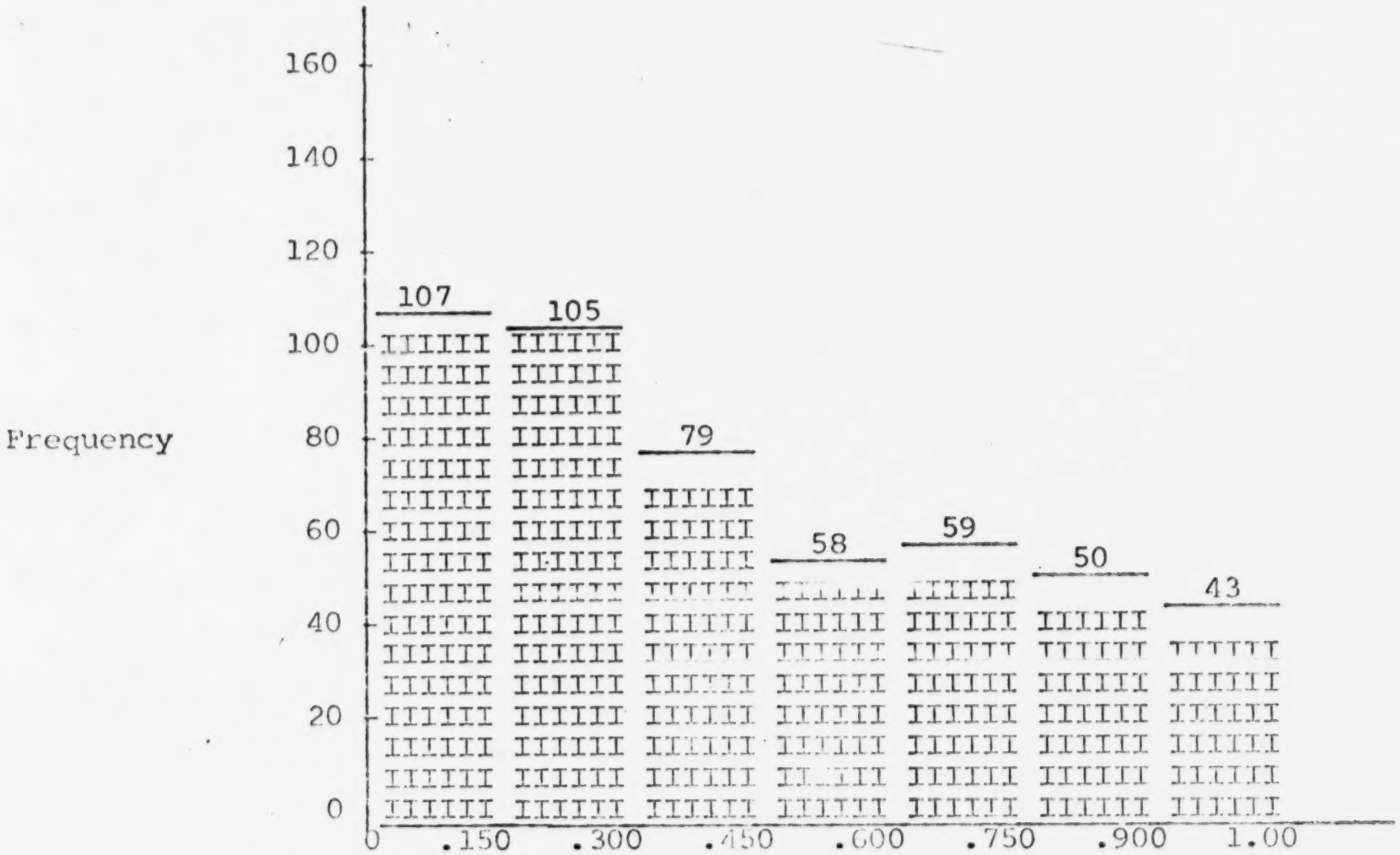

FIGURE 4

POSTTEST PEER ESTEEM HISTOGRAM OF RAW SCORE PROPORTIONS FOR TOTAL SAMPLE

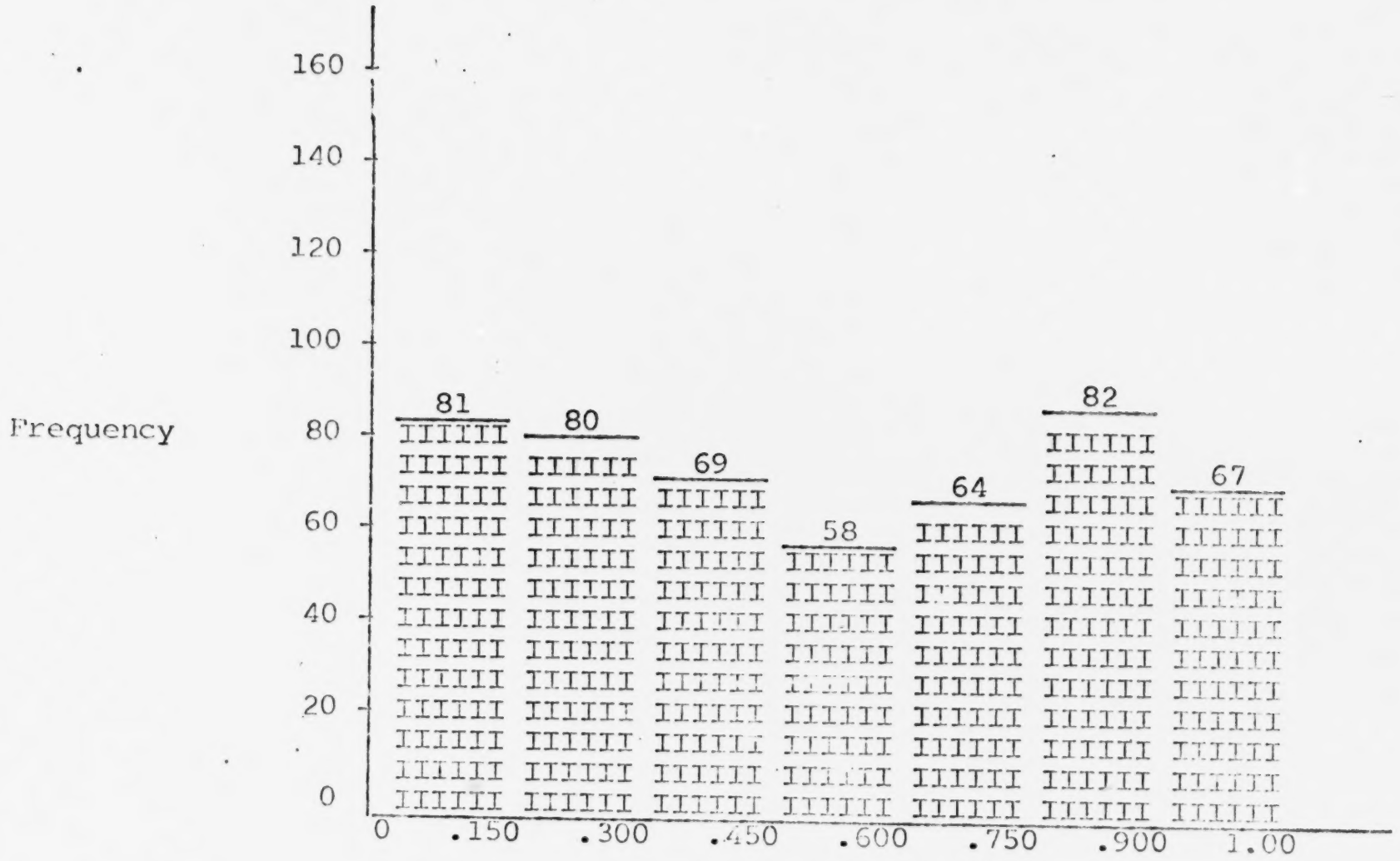

FIGURE 5

PRETEST TEACHER ESTEEM HISTOGRAM OF RAW SCORE PROPORTIONS FOR TOTAL SAMPLE

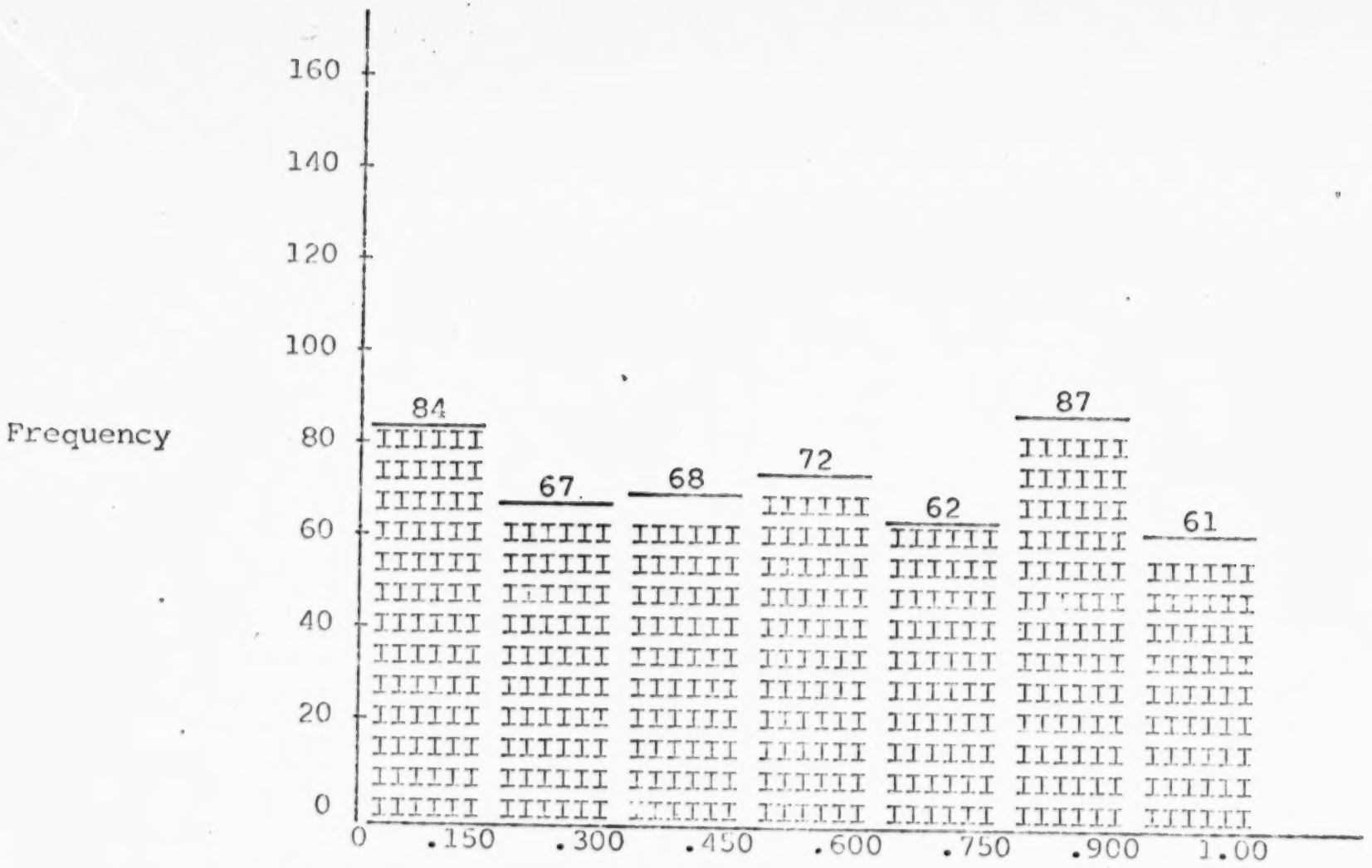

FIGURE 6

POSTTEST TEACHER ESTEEM HISTOGRAM OF RAW SCORE PROPORTIONS FOR TOTAL SAMPLE

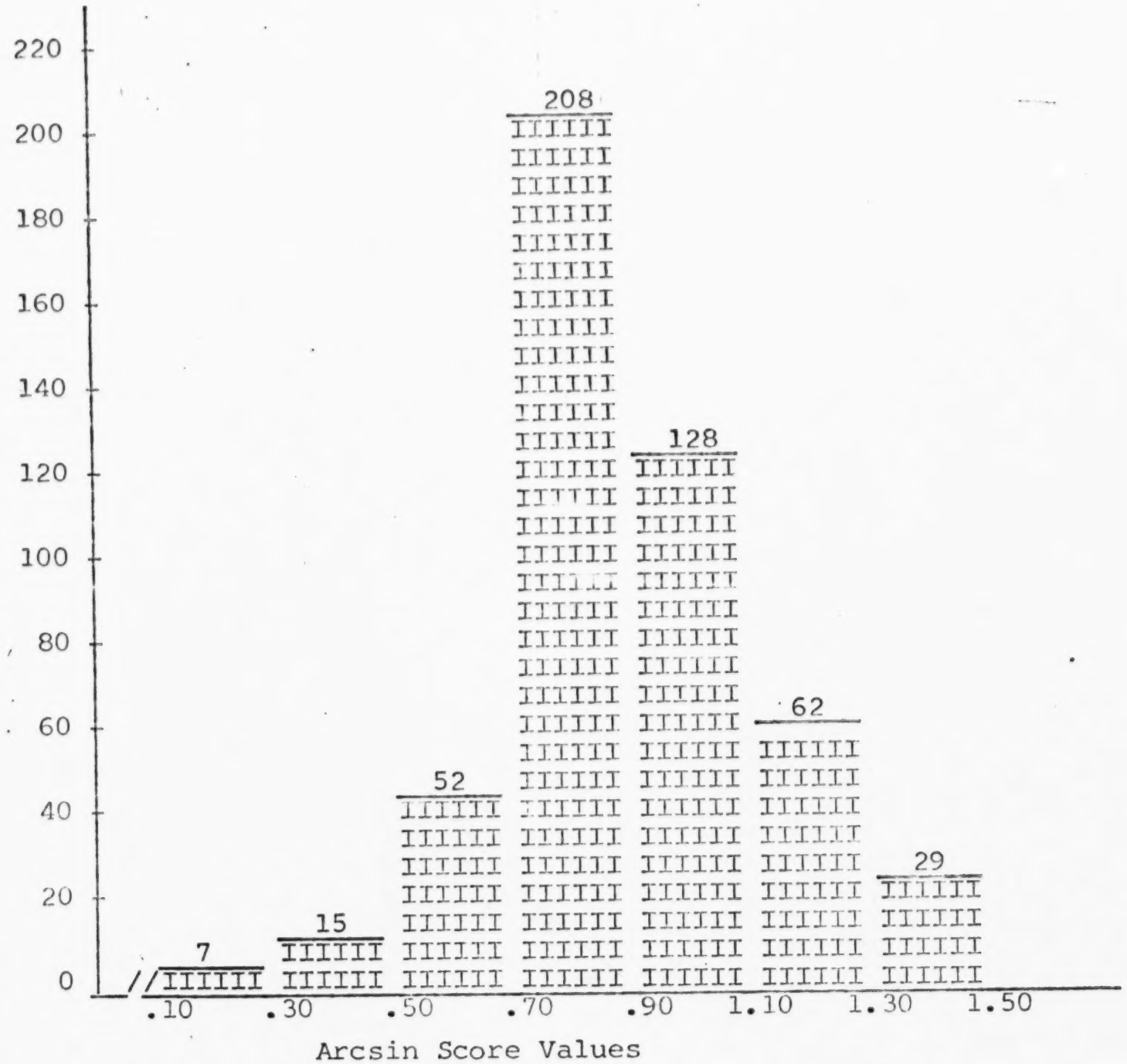

FIGURE 7

PRETEST SELF ESTEEM HISTOGRAM OF TRANSFORMED SCORES IN ARCSIN VALUES FOR TOTAL SAMPLE

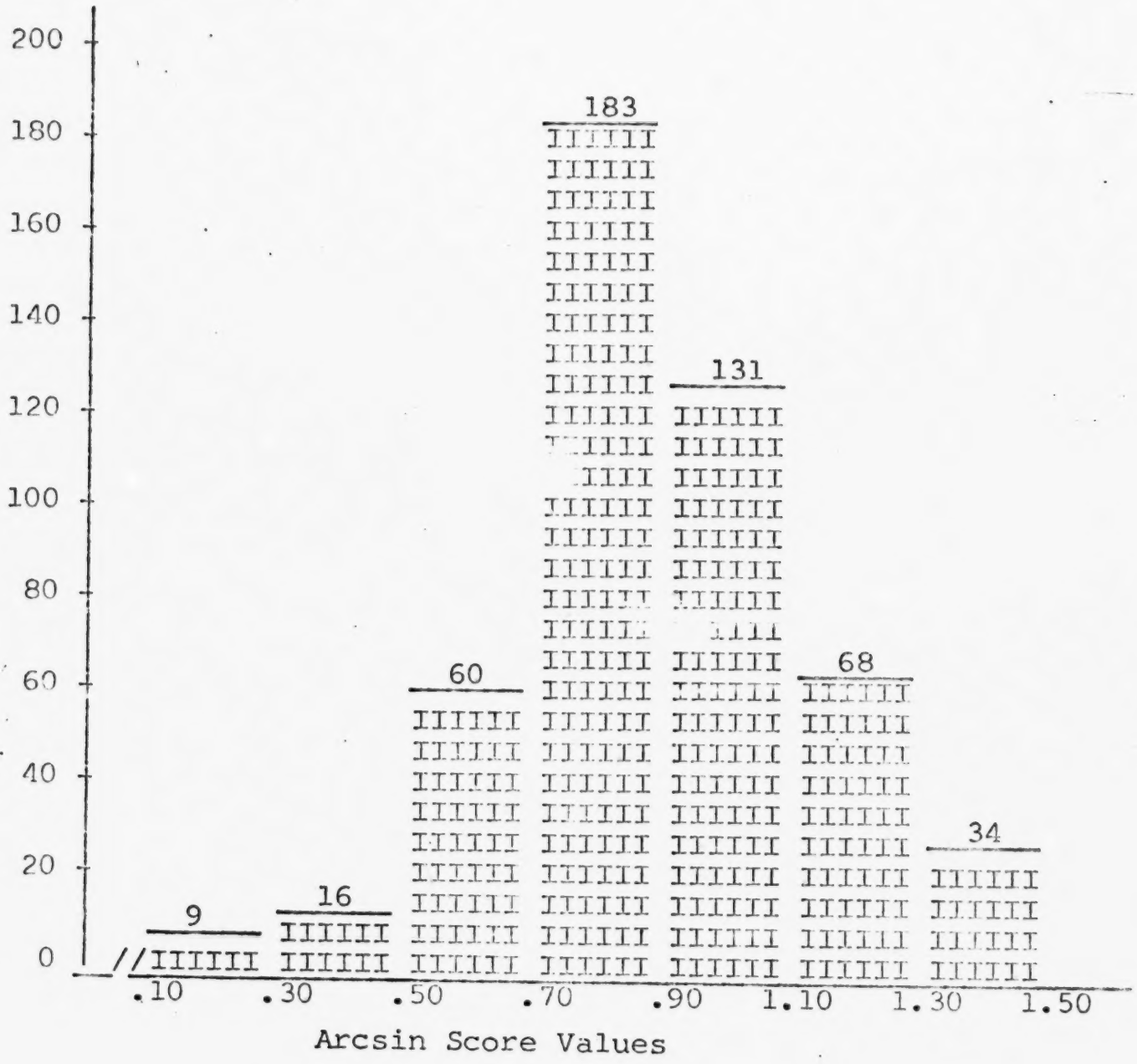

FIGURE 8

POSTTEST SELF ESTEEM HISTOGRAM OF TRANSFORMED SCORES IN ARCSIN VALUES FOR TOTAL SAMPLE

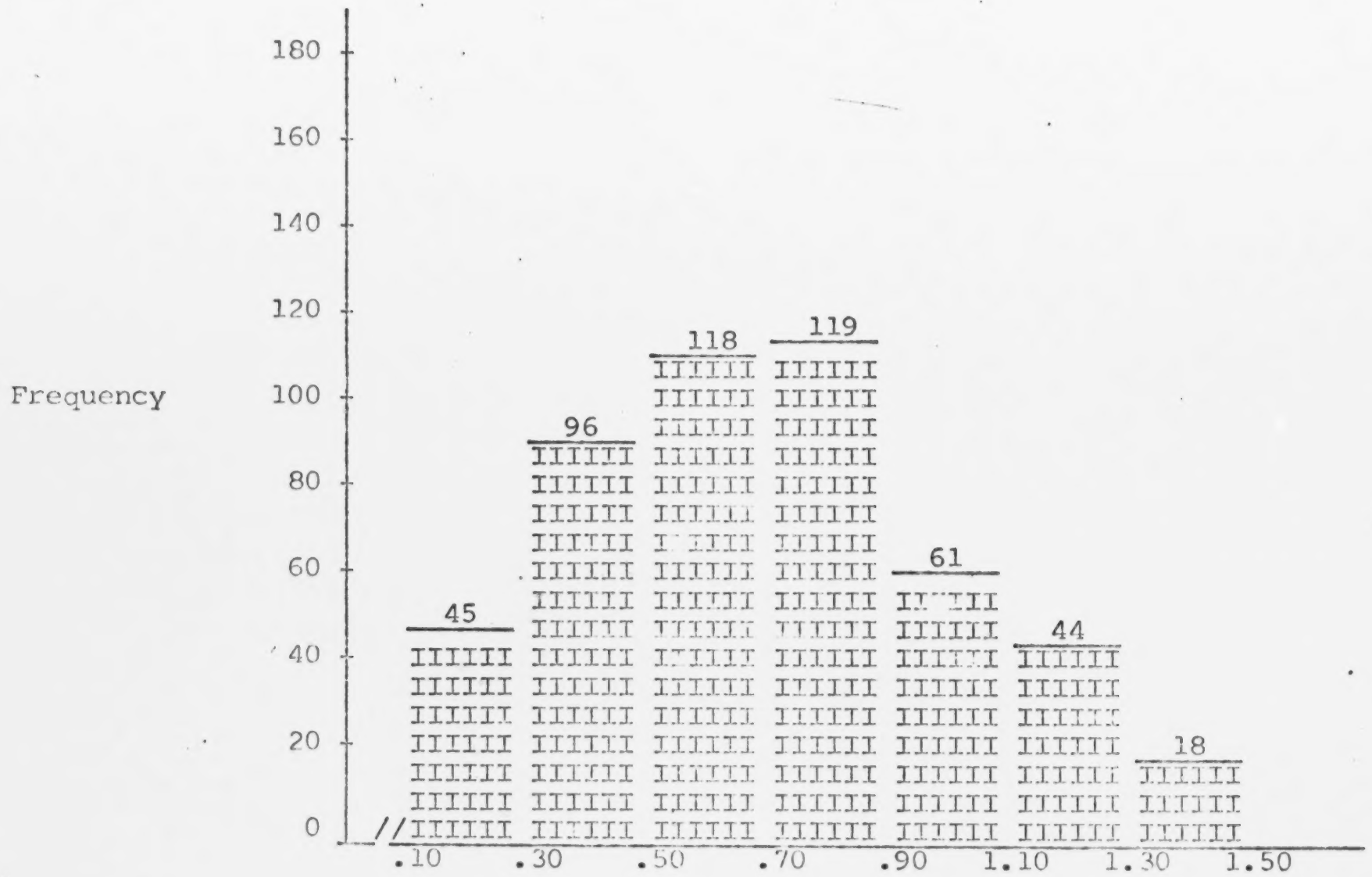

FIGURE 9

PRETEST PEER ESTEEM HISTOGRAM OF TRANSFORMED SCORES IN ARCSIN VALUES FOR TOTAL SAMPLE

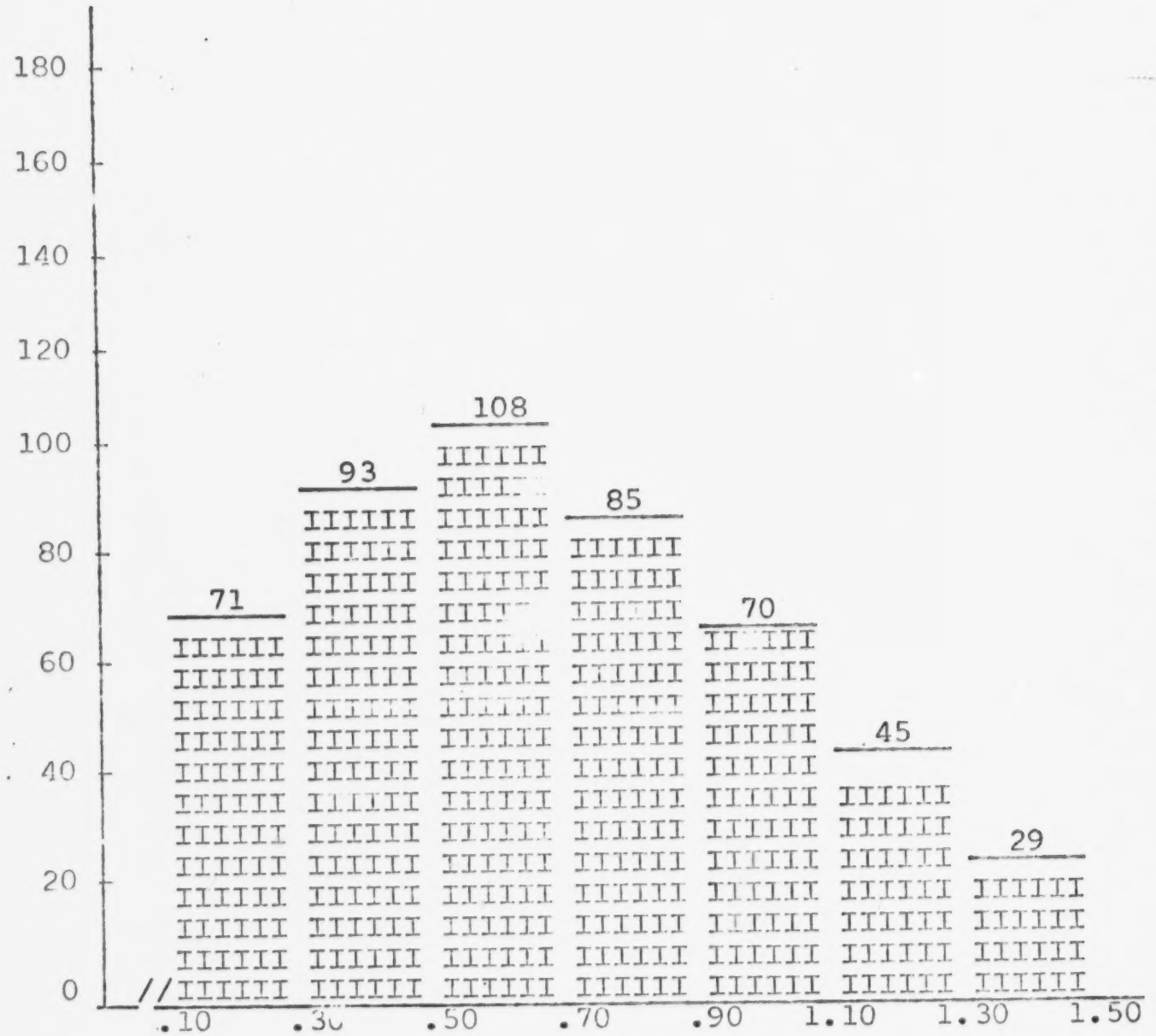

FIGURE 10

POSTTEST PEER ESTEEM HISTOGRAM OF TRANSFORMED SCORES IN ARCSIN VALUES FOR TOTAL SAMPLE

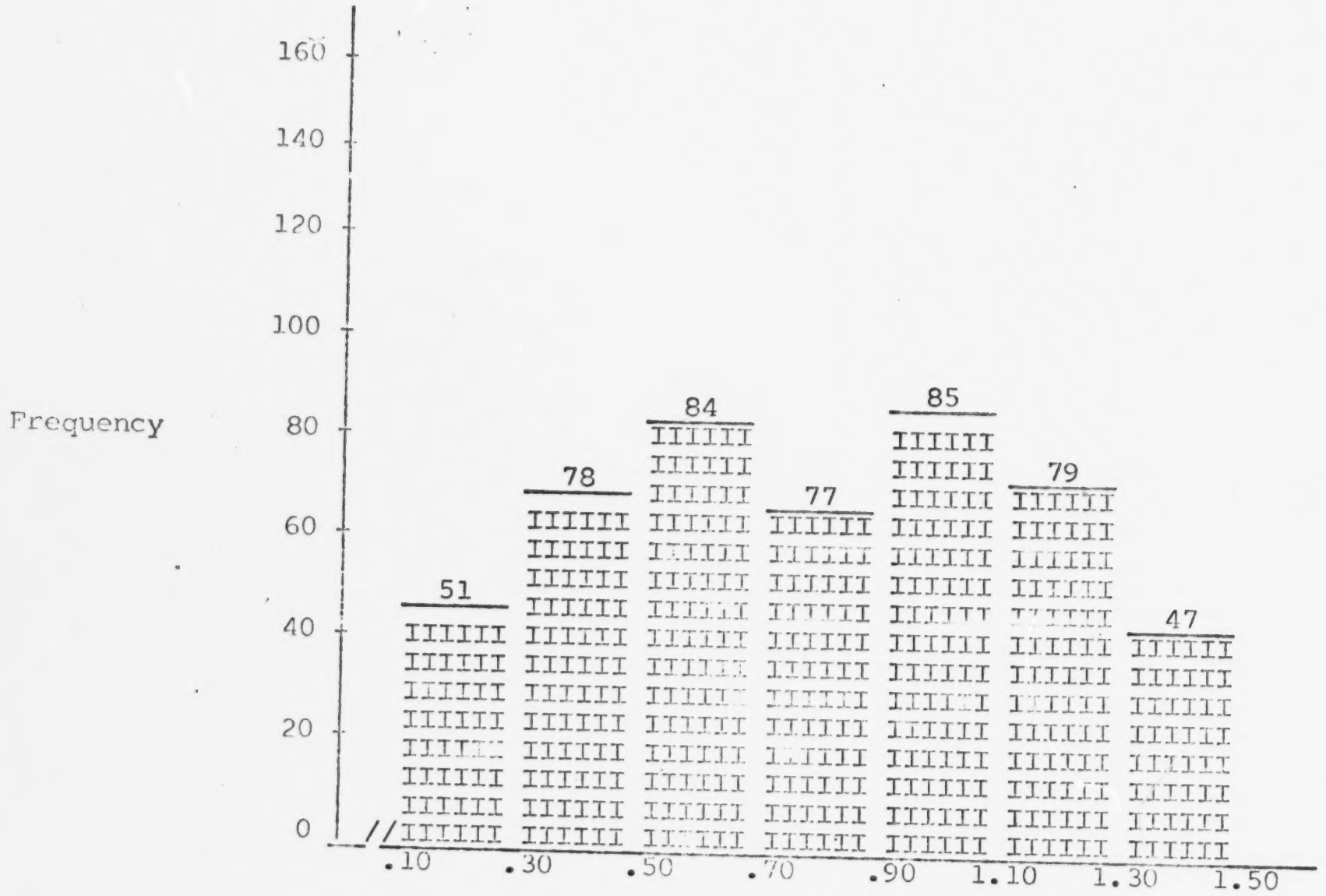

FIGURE 11

PRETEST TEACHER ESTEEM HISTOGRAM OF TRANSFORMED SCORES IN ARCSIN VALUES FOR TOTAL SAMPLE

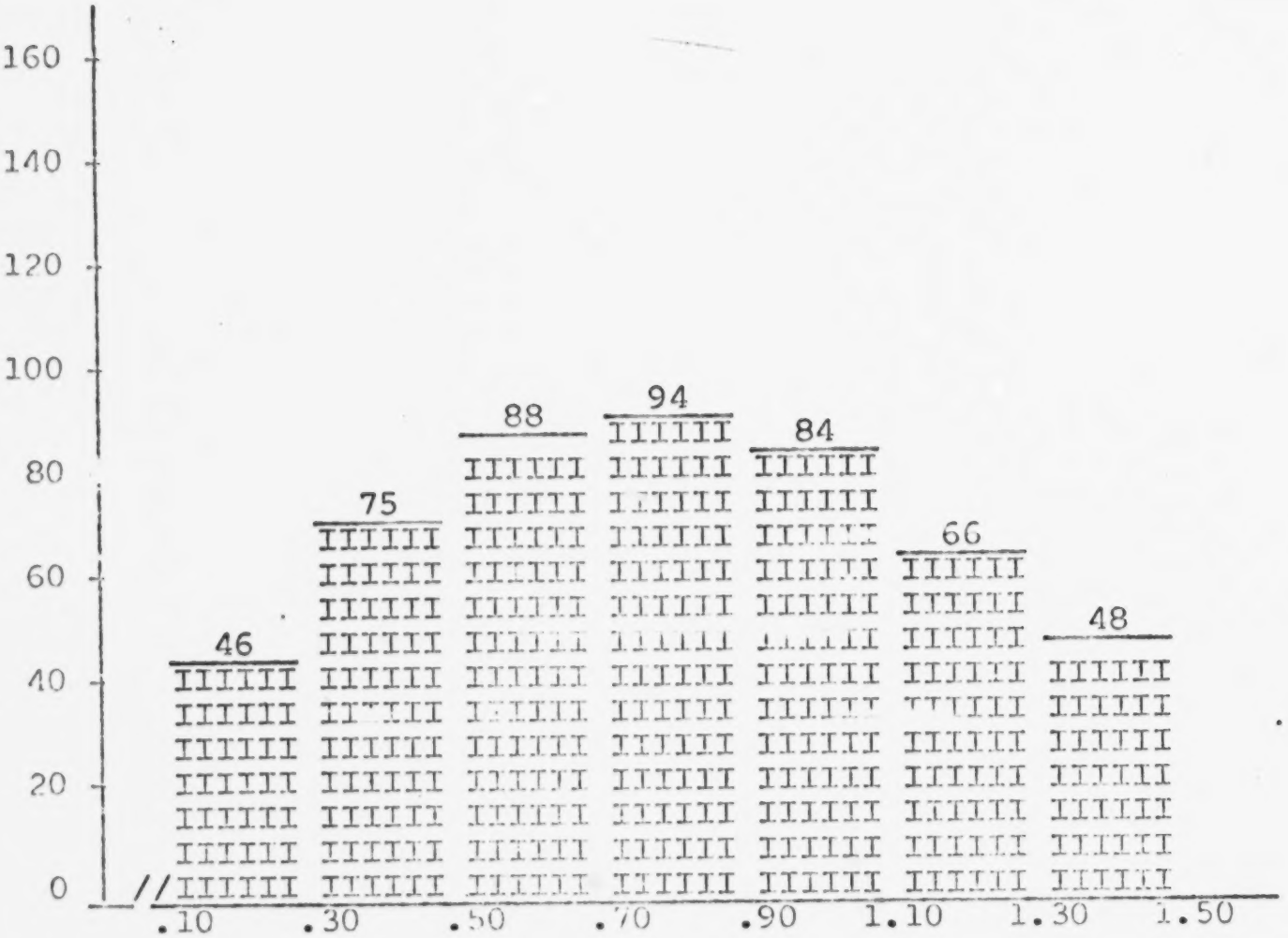

FIGURE 12

POSTTEST TEACHER ESTEEM HISTOGRAM OF TRANSFORMED SCORES IN ARCSIN VALUES FOR TOTAL SAMPLE

TABLE I

RESULTS OF KOLMOGOROV-SMIRNOV TESTS FOR
NORMALITY OF DISTRIBUTIONS OF
RAW SCORE PROPORTIONS

Variable	Distribution Normal ($P \leq .05$)	Distribution Exceeds Normality ($P \leq .05$)
Self Esteem (September)	X	
Self Esteem (February)	X	
Peer Esteem (September)		X
Peer Esteem (February)		X
Teacher Esteem (September)		X
Teacher Esteem (February)		X

TABLE II

ARCSIN TRANSFORMED SCORES OF PROPORTIONS OF CHOICES FROM SOCIOMETRIC QUESTIONNAIRES*

Proportion	Arcsin Score	Proportion	Arcsin Score	Proportion	Arcsin Score
.01	.1002	.34	.6225	.67	.9589
.02	.1419	.35	.6331	.68	.9695
.03	.1741	.36	.6435	.69	.9803
.04	.2014	.37	.6539	.70	.9912
.05	.2255	.38	.6642	.71	1.0021
.06	.2475	.39	.6745	.72	1.0132
.07	.2678	.40	.6847	.73	1.0244
.08	.2868	.41	.6949	.74	1.0357
.09	.3047	.42	.7051	.75	1.0472
.10	.3218	.43	.7152	.76	1.0588
.11	.3381	.44	.7253	.77	1.0706
.12	.3537	.45	.7353	.78	1.0826
.13	.3689	.46	.7454	.79	1.0948
.14	.3835	.47	.7554	.80	1.1071
.15	.3977	.48	.7654	.81	1.1198
.16	.4115	.49	.7754	.82	1.1326
.17	.4250	.50	.7854	.83	1.1458
.18	.4381	.51	.7954	.84	1.1593
.19	.4510	.52	.8054	.85	1.1731
.20	.4636	.53	.8154	.86	1.1873
.21	.4760	.54	.8254	.87	1.2019
.22	.4882	.55	.8355	.88	1.2171
.23	.5002	.56	.8455	.89	1.2327
.24	.5120	.57	.8556	.90	1.2490
.25	.5236	.58	.8657	.91	1.2661
.26	.5351	.59	.8759	.92	1.2840
.27	.5464	.60	.8861	.93	1.3030
.28	.5576	.61	.8963	.94	1.3233
.29	.5687	.62	.9066	.95	1.3453
.30	.5796	.63	.9169	.96	1.3694
.31	.5905	.64	.9273	.97	1.3967
.32	.6013	.65	.9377	.98	1.4289
.33	.6119	.66	.9483	.99	1.4706

*Figures in this table were generated using a program "Transgeneration BMD09S," from W. J. Dixon, (ed.) Biomedical Computer Programs (Berkeley, California: University of California Press, 1967), pp. 421-429.

TABLE III

PEARSON PRODUCT MOMENT CORRELATION COEFFICIENTS BETWEEN ALL VARIABLES AS MEASURED IN SEPTEMBER AND FEBRUARY FOR TOTAL SAMPLE (N=501)*

Variables	1	2	3	4	5	6	7	8
1. Arithmetic (September)	1.00	.27	.42	.33	(.67)	.34	.44	.35
2. Self Esteem (September)		1.00	.44	.46	.28	(.57)	.44	.50
3. Peer Esteem (September)			1.00	.67	.40	.47	(.83)	.69
4. Teacher Esteem (September)				1.00	.30	.49	.68	(.73)
5. Arithmetic (February)					1.00	.31	.41	.35
6. Self Esteem (February)						1.00	.53	.57
7. Peer Esteem (February)							1.00	.75
8. Teacher Esteem (February)								1.00

*p < .005

( ) indicates test re-test reliability

TABLE IV

MEANS AND STANDARD DEVIATIONS OF SOCIOMETRIC
RAW SCORE PROPORTIONS AND TRANSFORMED SCORES

Variable	Raw Score Mean	Raw Score S.D.	Transformed Score Mean	Transformed Score S.D.
Self (September)	.59	.20	.88	.23
Self (February)	.60	.21	.89	.24
Peer (September)	.42	.26	.70	.30
Peer (February)	.42	.29	.69	.34
Teacher (September)	.50	.30	.79	.36
Teacher (February)	.51	.30	.79	.35